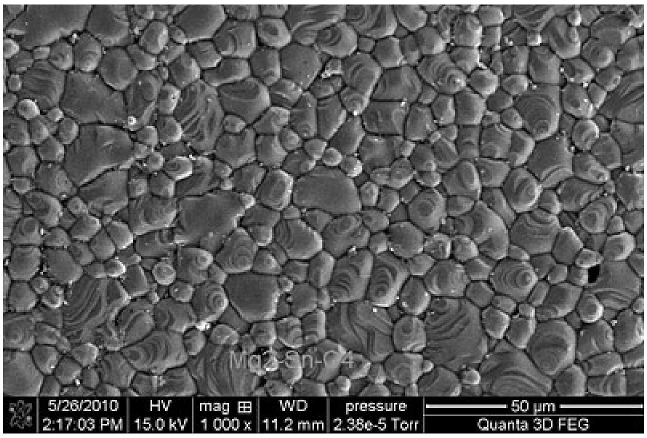


The two experiments are testing out new types of nuclear materials, such as this ceramic (scanning electron microscope image).

Post-irradiation work begins for first university experiments to come out of INL's Advanced Test Reactor

By Mike Wall, *INL Communications and Governmental Affairs*

The fun part has just begun for Walid Mohamed. The North Carolina State University doctoral student and his supervisor, NCSU nuclear engineering professor K.L. Murty, spent nearly two years preparing an experiment for insertion into Idaho National Laboratory's Advanced Test Reactor. In March, the pair's first samples came out of the ATR. And now Mohamed is getting to see how those samples held up under the reactor's intense neutron irradiation.

NCSU's Murty (left) and Mohamed in the lab, working with a machine that gauges materials' tensile properties.

The NCSU team's project was one of the first four chosen by INL's ATR National Scientific User Facility back in 2008. The ATR NSUF grants university-led scientific groups access to the ATR — one of the world's most versatile research reactors — and other resources at INL and affiliated institutions. The goal is to advance nuclear-energy technology via cutting-edge research and development, thus helping enhance the nation's energy security.

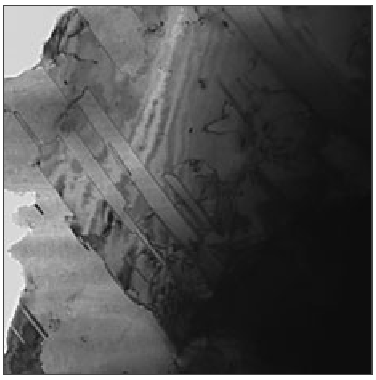
An experiment led by the University of Florida also started doing post-irradiation examination (PIE) recently, and several other projects will soon do the same. The PIE work represents another important milestone for the ATR NSUF, which was established by the U.S. Department of Energy in 2007.

"We've now proven we can get most of the way through an experiment," says INL's Todd Allen, director of the ATR NSUF. "We can get through the design and execution phases based on a university's input."

Searching for stronger nuclear materials

Murty and Mohamed are working with INL researcher Doug Porter to determine how radiation affects nanocrystalline materials, which are very finely structured on the atomic scale. Nanocrystals are composed of many minuscule grains, far more per unit area than are found in traditional nuclear materials.

Theoretically, smaller, more densely packed grains should help protect turbine blades, fuel cladding and other reactor components against radiation damage, because the boundaries between grains tend to absorb and mitigate radiation-induced defects. But few researchers have performed in-depth work with nanocrystals, so the NCSU team is putting that theory to the test.



A transmission electron microscope image of irradiated nanocrystalline material.

At INL's Materials and Fuels Complex (MFC), Mohamed is examining irradiated nanocrystalline copper, nickel and steel. He's looking for defects in the materials using several methods, including transmission electron microscopy (TEM) and X-ray diffraction. And he's testing the materials' mechanical properties, too, to see if irradiation makes them softer or more brittle.

Though a lot of work remains to be done, the NCSU team already has some interesting results.

"At least for copper, we're seeing grain growth," Mohamed says. "This is significant. One big advantage of nanocrystalline materials is having really fine grains. So if you get grain growth under irradiation, that advantage may be negated."

Over the next few months, Mohamed will see if nanocrystalline nickel and steel show similar post-irradiation properties. He hopes to be done with this work, and his PhD, by the end of the year.

Helping develop advanced nuclear fuels

The University of Florida project is also testing out new types of materials. But the UF team, led by materials science and engineering professor Juan Nino, is interested in improving nuclear fuels rather than finding better structural materials.

Nino, UF master's student Donald Moore and INL scientist Pavel Medvedev are looking for materials that would make good inert matrix fuels (IMFs). When today's commercial power reactors "burn" uranium, they generate plutonium and other radioactive elements. IMFs incorporate these so-called transuranics as fuel, allowing reactors to burn up or transmute them — and therefore produce less radioactive waste.

Nino and his colleagues synthesized several potential IMF ceramics — without the transuranics — back in Gainesville. They irradiated the materials in the ATR, and now Moore is starting to investigate the effects at MFC. He's looking for radiation defects and swelling in the materials using TEM and scanning electron microscopy. He'll also see how irradiation has changed the ceramics' heat-conducting properties, if at all.

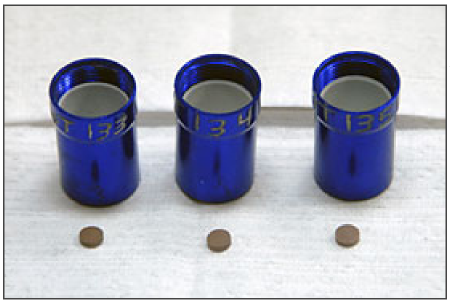

INL's Pavel Medvedev (left) with University of Florida graduate student Donald Moore.

This work should occupy Moore for the next year or so. But if he identifies any promising materials, Nino's group will follow those leads far into the future.

"The next step would be mixing the ceramic with fuel and testing how the IMF performs under irradiation," Moore says.

An evolving ATR NSUF
The NCSU and UF experiments are just two of 20 the ATR NSUF has chosen during its brief lifetime. And more will continue to come aboard; the facility picks new projects twice a year, following the closure of rolling application periods in April and November.

"There's tremendous interest," Allen says. "We're getting four times more applications than we can possibly accommodate."


Samples of some ceramics the UF-led project has been irradiating in the ATR.

As the first few university-led projects have progressed and matured, so has the ATR NSUF itself. Allen says he has learned a lot in the last two years, and he anticipates making some tweaks to the program in the future. Allen foresees, for example, teaming more with other facilities, such as Argonne National Laboratory's Advanced Photon Source, or the research reactor at the National Institute of Standards and Technology — whatever's needed to answer the questions researchers have posed.

"I think you'll see us transitioning more and more to a nuclear energy user facility, not just the ATR user facility," he says.

But the essence of the ATR NSUF, and its mission, won't waver.

"We take capabilities that don't exist in many other places, and we pair them with the best ideas out there," Allen says. "That's what we do, and that's not going to change."

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